2.1.1 Physical quantities

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	physical quantities have a numerical value and a unit	*M0.1*
(b)	making estimates of physical quantities listed in this specification.	*M0.4*

2.1.2 S.I. units

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	Système Internationale (S.I.) base quantities and their units – mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)	HSW8
(b)	derived units of S.I. base units	Examples: momentum $\longrightarrow$ kg m s^{-1} and density $\longrightarrow$ kg m^{-3}
(c)	units listed in this specification	
(d)	checking the homogeneity of physical equations using S.I. base units	
(e)	prefixes and their symbols to indicate decimal submultiples or multiples of units – pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)	As set out in the ASE publication *Signs, Symbols and Systematics* (*The ASE Companion to 16–19 Science*, 2000).
(f)	the conventions used for labelling graph axes and table columns.	As set out in above, e.g. speed / m s^{-1}. HSW8

(6) M - Make reasoned estimates of physics quantities
(7) S - Derive units from equations and base units
(8) C - Show that equations are homogenous with respect to units

Lesson 2. Derived units

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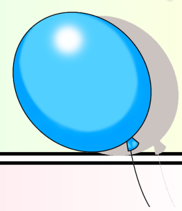
STARTER: Prefixes and orders of magnitude mini test.



Kilo 10^3

Mega 10^6 How does the temperature of the gas relate to the

Giga 10^9

nm

Key point

1. mega 10^6 ✓
2. n 10^{-9} ✓
3. 10^{-6} μ / micro ✓
4. 10^{-12} Pico
5. 10^6 Mega
6. Kilo 10^3
7. G 10^9
8. μ 10^{-6}
9. Centi 10^{-2}
10. 10^{15} Peta.

/10

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Deriving units from base units

Key point

Newtons are the SI unit for force, but is is a derived unit.

We can find which **base units** derive this unit by using a related equation.

E.g.

$F = m \times a$

$N = kg \times ms^{-2}$

$N = kgms^{-2}$ SI Base unit.

Task 1: Find the missing information for each row

Physical quantity	Equation used	Unit	Derived unit symbol and name
frequency	$\frac{1}{\text{time period}}$	**a**	Hz hertz
volume	length^3	**b**	–
acceleration	$\frac{\text{velocity}}{\text{time}}$	**c**	–
force	mass × acceleration	kg m s^{-2}	**d**
work and energy	force × distance	**e**	J joule
voltage	$\frac{\text{energy}}{\text{electric charge}}$	J C^{-1}	**f**
electrical resistance	**g**	V A^{-1}	**h**
momentum	mass × velocity	**i**	–
impulse	force × time	**j**	–
k	$\frac{\text{force}}{\text{area}}$	**l**	Pa pascal
m	**n**	kg m^{-3}	–

Extension: Check this equation is **homogenous** with respect to units.

$$\text{kinetic energy} = \frac{1}{2} m v^2$$

(6) M - Make reasoned estimates of physics quantities
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Answers

1 a s^{-1}

b m^3

c $m\,s^{-2}$ $\quad \frac{m/s}{s} \quad \frac{m}{s \times s} \quad m/s^2 \quad m s^{-2}$

d N newton

e $kg\,m^2\,s^{-2}$ (allow N m, remind students that this is a derived unit)

f V volt $\quad \boxed{J C^{-1}} \quad It = Q \quad As = C$

$kg m^2 s^{-2} \times C^{-1}$

$\boxed{kg m^2 s^{-2} A^{-1} s^{-1}}$

g $\frac{\text{voltage}}{\text{current}}$

h Ω ohm

i $kg\,m\,s^{-1}$

j N s $\quad kg m s^{-2} s \quad kg m s^{-1}$

k pressure

l $N\,m^{-2}$ $\quad kg m s^{-2} m^{-2} \quad kg m^{-1} s^{-2}$

$kg m^{-1} s^{-2}$

m density

n Mass / Vol.

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Homogeneity

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Key point

Read the ideas about homogeneity at the top of the sheet.

Example: kinetic energy $= \frac{1}{2} m v^2$

$W = F \times s$

$J = Nm$

$J = kgms^{-2}m$

$kgm^2s^{-2} = kg\,m^2s^{-2}$

$J = kg(ms^{-1})^2$

$kg(ms^{-1})(ms^{-1})$

$kg\,m^2s^{-2}$

Homogeneity

The units on both sides of an equation must be equivalent otherwise the equation cannot be correct. If the units are fundamentally different then the quantities on the different sides of the equal sign cannot be equivalent. A velocity cannot be the same as an acceleration: they have different units.

This homogeneity is a consequence of the precise definitions of quantities in physics, which ensures a logical and mathematical consistency. Note that it is possible for the units to be homogenous when the relationship itself is not correct.

The principle of homogeneity allows us to:

- deduce the units of an unknown value (constant or variable) in an equation
- check that an equation shows a possible physical relationship.

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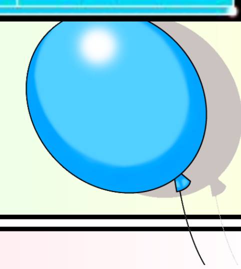
<u>**Estimation in physics**</u>


Key point

Activity: In pairs make a rough but reasoned estimate of the quantities on the sheet.



Kilo 10^3

Mega 10^6

Giga 10^9

Extension estimate below....

Why is estimation important to physics?

'How many pingpong balls fit in this room?'

How thick is a piece of paper?

How many hairs on a human head?'

How many teaspoons of water in the pond?'

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Plenary

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